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QUESTION BANK

Name of the Department : **Mechanical Engineering**

Subject Code & Name : **ME 8097 & Non Destructive Testing & Evaluation**

Year & Semester : **IV & VII**

UNIT I

OVERVIEW OF NDT

1) What are the methods to examine the defects in theZ products?
   1. Non-Destructive Testing
   2. Non-Destructive Evaluation
   3. Non-Destructive Inspection

2) Define: Non-Destructive Testing?

The method of testing or inspection of a component or material to detect the presence of any defect without damaging it is called Non-Destructive Testing.

3) What are the benefits of a Non-Destructive Testing of products?

i) They provide the information on the quality of the material or component without damaging. ii) Presence of defects can be detected both at the manufacturing stage as well as during service.

iii) this helps to prevent failure in service and results in not only financial saving but saving of human lives also.

4) What are the defects that can be identified by NDT techniques?

Both external defects such as cracks, discontinuities, marks, porosities and internal defects such as blow holes, porosities, welding discontinuities etc. can be identified by NDT techniques.

5)What are the advantages of Non-Destructive Testing over Destructive Testing?

Sl. No	Non-Destructive Testing(advantages)	Destructive Testing(limitation)
1.	Tests are made directly on the object.100% testing on actual components is possible.	Tests are not made directly on the objects. Hence correlation between the sample.
2.	In-service testing is possible	In-service testing is not possible
3.	Repeated checks over a period of time are possible.	Repeated checks over a period of time are not possible.

4.	Very little preparation is sufficient.	Preparation of the test specimen is costly.

8) Name some new methods of NDT?

i) Neutron radiography

ii) Acoustic emission

iii)Thermography

iv) Strain sensing

v) Microwave technique

vi) Holography

9) What are the factors to be considered for the choice of specific NDT methods?

i) Availability based on analysis

10) What is Visual Inspection?

A simple visual test can reveal gross surface defects thus leading to an immediate rejection of the component and consequently saving much time and money. They provide information on the quality of a material or component without damaging it.

11) What is the basic principle of Visual Inspection?

The basic procedure used in visual NDT involves illumination of the specimen with light, usually in the visible region. The specimen is then examined with eye or by light sensitive devices such as photocells.

12) What is the important tool in NDT method?

The most valuable NDT tool is the human eye. The eye has excellent visual perception. The sensitivity of the human eye varies for light with different wavelengths. Under ordinary conditions, the eye is most sensitive to yellowgreen light, which has a wavelength of 5560 A^0.

13) What is the prime importance of visual inspection?

For Visual Inspection, adequate lighting about 800-1000 lux is needed. The period of time during which a human inspector is permitted to work should be limited to not more than 2 hours on continuous basis to avoid errors due to decrease in visual reliability and discrimination.

14) What are the information which can revealed by Visual Inspection of a component?

a) The general condition of the component.

b) The presence or absence of oxide film or corrosive product on the surface.

c) The presence or absence of cracks, orientation of cracks and the position of cracks relative to the various zones in the case of welds

d) The surface porosity, infilled craters, contour of the weld beads, and the probable orientation of the interface between the fused weld bead and the adjoining parent metal.

15) What is the use of optical aid instruments in visual inspection?

a) To magnify defects that cannot be detected by the unaided eye.

b) To permit visual checks of areas not accessible to the unaided eye.

16) What is optical microscope?

An optical microscope is a combination of lenses used to magnify the image of a small object. The object is placed close to the lens to obtain as high a magnification as possible.

PART B 16 MARKS

1. Discuss briefly about the visual inspection and instruments used for visual inspection? (16)

Visual testing (VT) is the oldest and most common nondestructive testing (NDT) techniques. It is typically the first step in the examination process to inspect a variety of product forms including castings, forgings, machined components and weld elements, according to the NDT Training & Test Center.

Compared to other techniques, visual testing is low in cost and easy to apply, and often eliminates the need for further types of testing. Some of the industries that use VT include structural steel, automotive, petrochemical, power generation, and aerospace.

Visual Testing Defined

According to a report from the U.S. Department of Transportation Federal Aviation Administration, Visual Inspection Research Project Report on Benchmark Inspections, "Visual inspection is the process of examination and evaluation of systems and components by use of human sensory systems aided only by mechanical enhancements to sensory input such as magnifiers, dental picks, stethoscopes, and the like. The inspection process may be done using such behaviors as looking, listening, feeling, smelling, shaking, and twisting.

"It includes a cognitive component wherein observations are correlated with knowledge of structure and with descriptions and diagrams from service literature."

Other NDT Methods Rely on VT

Other NDT methods require visual intervention to interpret images obtained while carrying out the examination. At some point, all NDT methods fall back on VT.

Liquid penetrant testing, for example, uses dyes that rely on the inspector's ability to visually identify surface indications. Magnetic particle testing falls into a similar category. Radiographic techniques require that the technician use visual judgment to determine the soundness of the object being tested.

Visual testing often locates areas where other NDT techniques need to be applied, or areas where mechanical and optical aids may provide improved inspection.

Visual Testing Requirements

In its paper on visual testing, the American Welding Society (AWS) said that requirements for visual testing typically pertain to three areas:

- The inspector's vision;
- The amount of light falling on the specimen, which is measured using a light meter; and
- Whether the area being inspected is obstructed from view.

Mechanical and Optical Aids Used in VT

Mechanical or optical aids are often necessary to perform visual testing.

These include such items as:

- Boroscopes
- Magnifying glasses
- Micrometers
- Mirrors
- UV Lights

Tech Service Products offers all of these devices in its NDT catalog.

The NDT Training & Test Center recommends that the specimen being tested should be well illuminated and has a clean surface. As specifications and tolerances become closer, mechanical and optical aids can help improve the precision of an inspector's vision.

Despite the advance in NDT technology, visual testing will continue to be a technique many industries rely on to ensure that the highest quality examination takes place.

2. Discuss in detail about the Relative merits and limitations, Various physical characteristics of materials and their applications in NDT. (8)

NDT Applications and Limitations

Non-destructive testing (NDT) are non-invasive techniques to determine the integrity of a material, component or structure or quantitatively measure some characteristic of an object. In contrast to destructive testing, NDT is an assessment without doing harm, stress or destroying the test object. The destruction of the test object usually makes destructive testing more costly and it is also inappropriate in many circumstances.

NDT plays a crucial role in ensuring cost effective operation, safety and reliability of plant, with resultant benefit to the community. NDT is used in a wide range of industrial areas and is used at almost any stage in the production or life cycle of many components. The mainstream applications are in aerospace, power generation, automotive, railway, petrochemical and pipeline markets. NDT of welds is one of the most used applications. It is very difficult to weld or mould a solid object that has no risk of breaking in service, so testing at manufacture and during use is often essential.

While originally NDT was applied only for safety reasons it is today widely accepted as cost saving technique in the quality assurance process. Unfortunately NDT is still not used in many areas where human life or ecology is in danger. Some may prefer to pay the lower costs of claims after an accident than applying of NDT. That is a form of unacceptable risk management. Disasters like the railway accident in Eschede Germany in 1998 is only one example, there are many others.

For implementation of NDT it is important to describe what shall be found and what to reject. A completely flawless production is almost never possible. For this reason testing specifications are indispensable. Nowadays there exists a great number of standards and acceptance regulations. They describe the limit between good and bad conditions, but also often which specific NDT method has to be used.

The reliability of an NDT Method is an essential issue. But a comparison of methods is only significant if it is referring to the same task. Each NDT method has its own set of advantages and disadvantages and, therefore, some are better suited than others for a particular application. By use of artificial flaws, the threshold of the sensitivity of a testing system has to be determined. If the sensitivity is to low defective test objects are not always recognized. If the sensitivity is too high parts with smaller flaws are rejected which would have been of no consequence to the serviceability of the component. With statistical methods it is possible to look closer into the field of uncertainly. Methods such as Probability of Detection (POD) or the ROC-method "Relative Operating Characteristics" are examples of the statistical analysis methods. Also the aspect of human errors has to be taken into account when determining the overall reliability.

Personnel Qualification is an important aspect of non-destructive evaluation. NDT techniques rely heavily on human skill and knowledge for the correct assessment and interpretation of test results. Proper and adequate training and certification of NDT personnel is therefore a must to ensure that the capabilities of the techniques are fully exploited. There are a number of published international and regional standards covering the certification of competence of personnel. The EN 473 (Qualification and certification of NDT personnel - General Principles) was developed specifically for the European Union for which the SNT-TC-1A is the American equivalent.

The nine most common NDT Methods are shown in the main index of this encyclopedia. In order of most used, they are: Ultrasonic Testing (UT), Radiographic Testing (RT), Electromagnetic Testing (ET) in which Eddy Current Testing (ECT) is well know and Acoustic Emission (AE or AET). Besides the main NDT methods a lot of other NDT techniques are available, such as Shearography Holography, Microwave and many more and new methods are being constantly researched and developed.

NDT Method	Applications	Limitations
Liquid Penetrant	• used on nonporous materials • can be applied to welds, tubing, brazing, castings, billets, forgings, aluminium parts, turbine blades and disks, gears	• need access to test surface • defects must be surface breaking • decontamination & precleaning of test surface may be needed • vapour hazard • very tight and shallow defects difficult to find • depth of flaw not indicated
Magnetic Particle	• ferromagnetic materials • surface and slightly subsurface flaws can be detected • can be applied to welds, tubing, bars, castings, billets, forgings, extrusions, engine components, shafts and gears	• detection of flaws limited by field strength and direction • needs clean and relatively smooth surface • some holding fixtures required for some magnetizing techniques • test piece may need demagnetization which can be difficult for some shapes and magetizations

		• depth of flaw not indicated
Eddy Current	• metals, alloys and electroconductors • sorting materials • surface and slightly subsurface flaws can be detected • used on tubing, wire, bearings, rails, nonmetal coatings, aircraft components, turbine blades and disks, automotive transmission shafts	• requires customized probe • although non-contacting it requires close proximity of probe to part • low penetration (typically 5mm) • false indications due to uncontrolled parametric variables
Ultrasonics	• metals, nonmetals and composites • surface and slightly subsurface flaws can be detected • can be applied to welds, tubing, joints, castings, billets, forgings, shafts, structural components, concrete, pressure vessels, aircraft and engine components • used to determine thickness and mechanical properties • monitoring service wear and deterioration	• usually contacting, either direct or with intervening medium required (e.g. immersion testing) • special probes are required for applications • sensitivity limited by frequency used and some materials cause significant scattering • scattering by test material structure can cause false indications • not easily applied to very thin materials
Radiography Neutron	• metals, nonmetals, composites and mixed materials	• access for placing test piece between source and detectors

	• used on pyrotechnics, resins, plastics, organic material, honeycomb structures, radioactive material, high density materials, and materials containing hydrogen	• size of neutron source housing is very large (reactors) for reasonable source strengths • collimating, filtering or otherwise modifying beam is difficult • radiation hazards • cracks must be oriented parallel to beam for detection • sensitivity decreases with increasing thickness
Radiography X-ray	• metals, nonmetals, composites and mixed materials • used on all shapes and forms; castings, welds, electronic assemblies, aerospace, marine and automotive components	• access to both sides of test piece needed • voltage, focal spot size and exposure time critical • radiation hazards • cracks must be oriented parallel to beam for detection • sensitivity decreases with increasing thickness
Radiography Gamma	• usually used on dense or thick material • used on all shapes and forms; castings, welds, electronic assemblies, aerospace, marine and automotive components • used where thickness or access limits X-ray generators	• radiation hazards • cracks must be oriented parallel to beam for detection • sensitivity decreases with increasing thickness • access to both sides of test piece needed • not as sensitive as X-rays

3. Write briefly about Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. (16)

Nondestructive testing or **Non-destructive testing** (**NDT**) is a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing damage. The terms **Nondestructive examination** (**NDE**), **Nondestructive inspection** (**NDI**), and **Nondestructive evaluation**(**NDE**) are also commonly used to describe this technology. Because NDT does not permanently alter the article being inspected, it is a highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research. Common NDT methods include ultrasonic, magnetic-particle, liquid penetrant, radiographic, remote visual inspection (RVI), eddy-current testing,[1] and low coherence interferometry NDT is commonly used in forensic engineering, mechanical engineering, petroleum engineering, electrical engineering, civil engineering, systems engineering, aeronautical engineering, medicine, and art.[1] Innovations in the field of nondestructive testing have had a profound impact on medical imaging, including on echocardiography, medical ultrasonography, and digital radiography.

Methods

NDT methods may rely upon use of electromagnetic radiation, sound, and inherent properties of materials to examine samples. This includes some kinds of microscopy to examine external surfaces in detail, although sample preparation techniques for metallography, optical microscopy and electron microscopy are generally destructive as the surfaces must be made smooth through polishing or the sample must be electron transparent in thickness. The inside of a sample can be examined with penetrating radiation, such as X-rays, neutrons or terahertz radiation. Sound waves are utilized in the case of ultrasonic testing. Contrast between a defect and the bulk of the sample may be enhanced for visual examination by the unaided eye by using liquids to penetrate fatigue cracks. One method (liquid penetrant testing) involves using dyes, fluorescent or non-fluorescent, in fluids for non-magnetic materials, usually metals.

Another commonly used NDT method used on ferrous materials involves the application of fine iron particles (either liquid or dry dust) that are applied to a part while it is in an externally magnetized state (magnetic-particle testing). The particles will be attracted to leakage fields within the test object, and form on the objects surface. Magnetic particle testing can reveal surface & some sub-surface defects within the part. Thermoelectric effect (or use of the Seebeck effect) uses thermal properties of an alloy to quickly and easily characterize many alloys. The chemical test, or chemical spot test method, utilizes application of sensitive chemicals that can indicate the presence of individual alloying elements. Electrochemical methods, such as electrochemical fatigue crack sensors, utilize the tendency of metal structural material to oxidize readily in order to detect progressive damage.

Analyzing and documenting a non-destructive failure mode can also be accomplished using a high-speed camera recording continuously (movie-loop) until the failure is detected. Detecting the failure can be accomplished using a sound detector or stress gauge which produces a signal to trigger the high-speed camera. These high-speed cameras have advanced recording modes to capture some non-destructive failures.[5] After the failure the high-speed camera will stop recording. The capture images can be played back inslow motion showing precisely what happen before, during and after the non-destructive event, image by image.

4. Discuss in detail about NDT vs Mechanical Testing? (6)

Mechanical & Non-Destructive Testing Fundamental Manufacturing Processes Study Guide, DV06PUB6 - 1 - Training Objective After watching the program and reviewing this printed material, the viewer will gain an understanding and become familiar with the various methods, equipment, and applications of mechanical and non-destructive materials testing. • Mechanical testing methods are clearly shown • Non-destructive testing methods are shown in detail

• Advantages and limitations of the various tests are detailed Materials Testing Prior to manufacturing, many material, design, and production decisions are made to ensure product reliability and proper performance. To validate these decisions, a variety of testing methods are employed. The methods are grouped into two major categories:

• Mechanical Testing • Non-Destructive Testing (NDT) Mechanical testing, which is also known as destructive testing, is accomplished by forcing a part to fail by the application of various load factors. In contrast, non-destructive testing does not affect the part's future usefulness and leaves the part and its component materials in tact.

Mechanical Testing Mechanical testing specifications have been developed by the American Society for Testing and Materials (ASTM) and many of these specifications have been adopted by the American National Standards Institute (ANSI). Typically mechanical testing involves such attributes as hardness, strength, and impact toughness. Additionally, materials can be subjected to various types of loads such as tension or compression. Mechanical testing can occur at room temperatures or in either high or low temperature extremes. Hardness – The resistance to indentation and to scratching or abrasion. The two most common hardness tests are the Brinell test and the Rockwell test. In the Brinell hardness test, a known load is applied for a given period of time to a specimen surface using a hardened steel or tungsten-carbide ball, causing a permanent indentation. Standard ball diameter is 10 millimeters, or approximately four-tenths of an inch. The diameter of the resulting permanent indentation is then measured and converted to a Brinell hardness number.

The Rockwell hardness test involves the use of an indentor for penetrating the surface of a material first by applying a minor, or initial load, and then applying a major, or final load under specific conditions. The difference between the minor and major penetration depths is then noted as a hardness value directly from a dial or digital readout. The harder the material the higher the number.

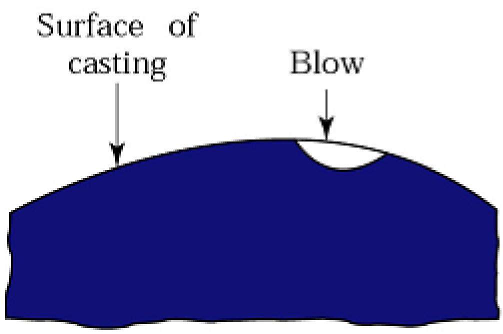
5. Discuss in detail about types of defects and it causes? (16)

Surface defects:

Due to design and quality of sand molds and general cause is poor ramming.

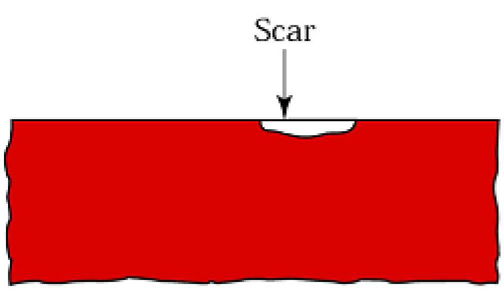
Blow:

Blow is relatively large cavity produced by gases which displace molten metal form.



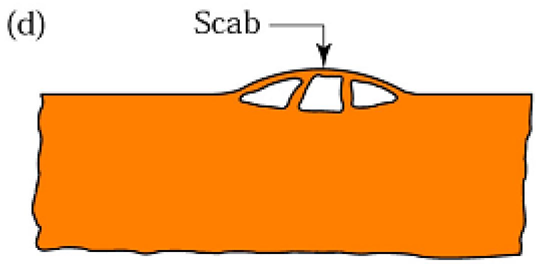
Scar:

Due to improper permeability or venting.A scare is a shallow blow. It generally occurs on flat surf; whereas a blow occurs on a convex casting surface. A blister is a shallow blow like a scar with thin layer of metal covering it,



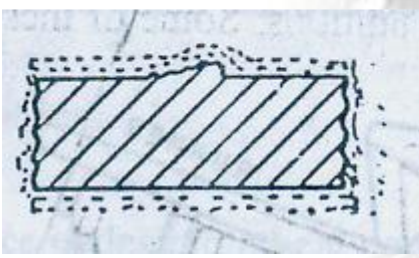
Scab:

This defect occurs when a portion of the face of a mould lifts or breaks down and the recess thus made is filled by metal. When the metal is poured into the cavity, gas may be disengaged with such violence as to break up the sand which is then washed away and the resulting cavity filled with metal. The reasons can be: - to fine sand, low permeability of sand, high moisture content of sand and uneven moulds ramming.



Drop:

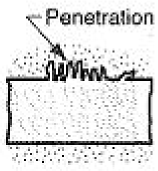
Drop or crush in a mould is an irregularly shaped projection on the cope surface of a casting. This defect is caused by the break-away of a part of mould sand as a result of weak packing of the mould, low strength of the molding sand, malfunctioning of molding equipment, strong jolts and strikes at the flask when assembling the mould. The loose sand that falls into the cavity will also cause a dirty casting surface, either on the top or bottom surface of the casting, depending upon the relative densities of the sand and the liquid.



Penetration:

It is a strong crust of fused sand on the surface of a casting which results from insufficient refractoriness of molding materials, a large content of impurities, inadequate mould packing and poor quality of mould washes.

When the molten metal is poured into the mould cavity, at those places when the sand packing is inadequate, some metal will flow between the sand particles for a distance into the mould wall and get solidified. When the casting is removed, this lump of metal remains attached to the casting. Of course, it can be removed afterwards by chipping or grinding.

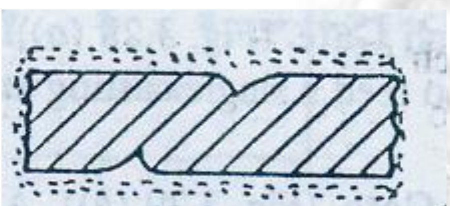


Buckle:

A buckle is a long, fairly shallow, broad, vee depression that occurs in the surface of flat castings. It extends in a fairly straight line across the entire flat surface.

It results due to the sand expansion caused by the heat of the metal, when the sand has insufficient hot deformation. It also results from poor casting design providing too large a flat surface in the mold cavity.

Buckling is prevented by mixing cereal or wood flour to sand.



Internal defects:

Blow holes:

Blow holes, gas holes or gas cavities are well rounded cavities having a clean and smooth surface. They appear either on the casting surface or in the body of a casting.

These defects occur when an excessive evolved gas is not able to flow through the mould. So, it collects into a bubble at the high points of a mould cavity ad prevents the liquid metal from filling that space.

This will result in open blows. Closed, cavities or gas holes are formed when the evolved gases or the dissolved gases in the molten metal are not able to leave the m ass of the molten metal as it solidifies and get trapped within the casting.

These defects are caused by :

i) excessive moisture content (in the case of green sand moulds) or organic content of the sand, moisture on chills, chaplets or metal inserts,

ii) inadequate gas permeability of the molding sand (due to fine grain size of sand, high clay content, hard ramming),

iii) poor venting of mould, insufficient drying of mould and cores, cores not properly vented, high gas content of the molten metal,

iv) low pouring temperature and incorrect feeding of the casting etc.

Pin holes:

Pin holes are small gas holes either at the surface or just below the surface. When these are present, they occur in large numbers and are fairly uniformly dispersed over the surface.

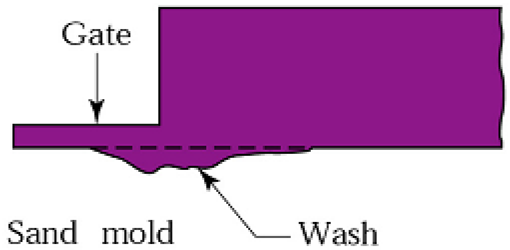
This defect occurs due to gas dissolved in the alloy and the alloy not properly degassed.

Visible defects:

Wash:

A cut or wash is a low; projection on the drag face of a casting that extends along the surface, decreasing in height as it extends from one side of the casting to the other end.

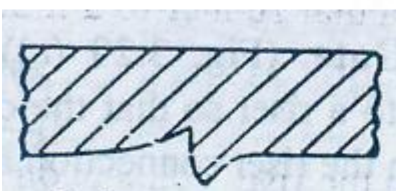
It usually occurs with bottom gating castings in which the molding sand has insufficient hot strength, and when too much metal is made to flow through one gate into the mold cavity,



Rat tail:

A rat tail is a long, shallow, angular depression in the surface of a flat rating and resembles a buckle, except that, it is not shaped like a broad vee.

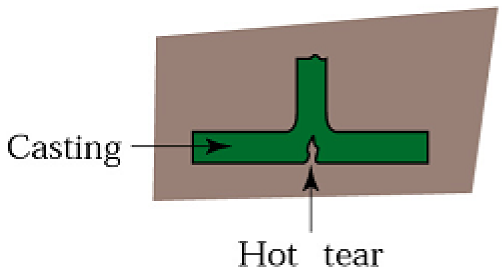
The reasons for this defect are the same for buckle.



Hot tear:

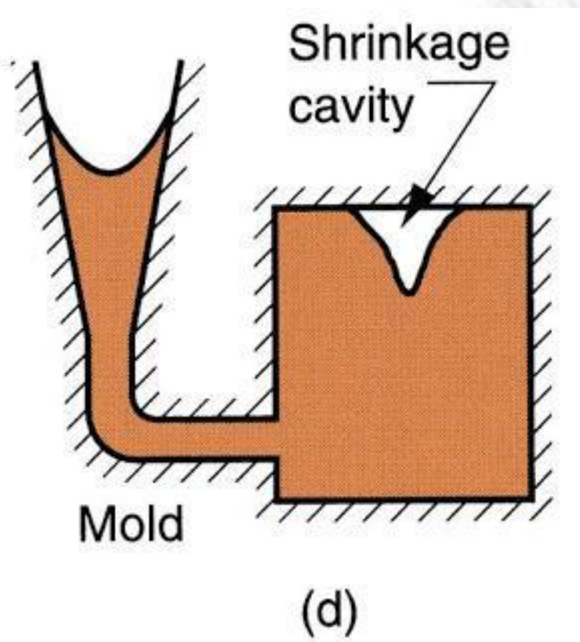
Hot tears are hot cracks which appear in the form of irregular crevices with a dark oxidizedfracture surface. They arise when the solidifying met does not have sufficient strength to resist tensile forces produced during solidification.

They are chiefly from an excessively high temperature of casting metal, increased metal contraction incorrect design of the gating system and casting on the whole (causing portions of the casting to be restrained from shrinking freely during cooling which in turn causes excessive high intern resistance stresses), poor deformability of the cores, and non-uniform cooling whichgives rise t internal stresses. This defect can be avoided by improving the design of the casting and by having a mould of low hot strength and large hot deformation.



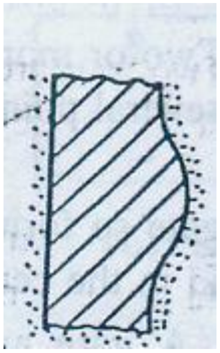
Shrinkage:

A shrinkage cavity is a depression or an internal void in a casting that results from the volume contraction that occurs during solidification.



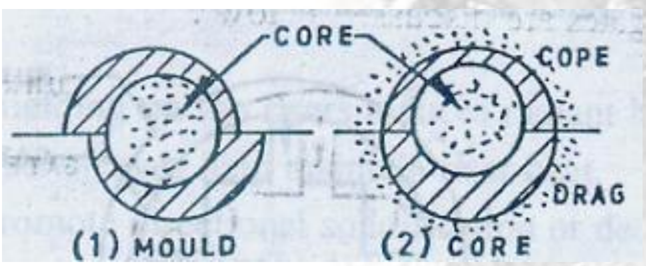
Swell:

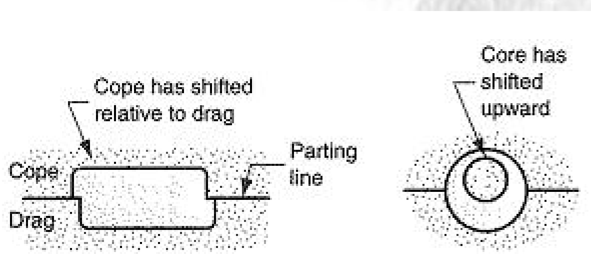
A swell is a slight, smooth bulge usually found on vertical faces of castings, resulting from liquid metal pressure. It may be due to low strength of mould because of too high a water content or when the mould is not rammed sufficiently.



Shift:

Mold shift refers to a defect caused by a sidewise displacement of the mold cope relative to the drag, the result of which is a step in the cast product at the parting line. Core shift is similar to mold shift, but it is the core that is displaced, and (he dis-placement is usually vertical. Core shift and mold shift are caused by buoyancy of the molten metal





UNIT-II

SURFACE NDE METHODS

1. What is Liquid Penetrant Inspection?

Liquid Penetrant Inspection is a non-destructive method of finding discontinuities/openings in the surface of a nonporous solid material.

2. State the principle of LPT?

The principle of Liquid Penetrant Testing is that a liquid applied to the test surface is drawn into the defect by capillary attraction. After subsequent cleaning of surface and application of developer powder, the liquid from the surface cavities are readily absorbed by the developer and rendered visible to the human eye.

3. Explain the procedure for the liquid penetrant testing?

- Cleaning
- Penetrant application
- Removal of excess penetrant
- Application of developer
- Inspection & evaluation

4. What are the penetrant testing materials used in LPT?

a) Penetrant

b) Cleaners and emulsifiers

c) Developers

d) Special requirements

e) Test blocks

5. What are the different types of penetrant testing methods?

- Water washable method
- Post-emulsifiable method
- Solvent removable method

6. What is penetrant?

The penetrant material consists of the indicating dye plus the carrier fluid. The indicating dye may give a colour contrast with respect to the surrounding, as is the case for visible dye penetrant methods, or a brightness contrast for the fluorescent dye penetrant.

7. What are the types of emulsifiers used in LPT?

1) Hydrophilic emulsifiers
2) Lipophilic emulsifiers

8. What are the advantages of LPT?

a) Comparatively simple as no electronic systems are involved.
b) Equipment is cheaper
c) Can be employed to any material except porous materials
d) Suitable for in situ inspection.

9. What are the limitations of LPT?

a) It can detect surface-breaking defects only.
b) Not suitable for rough surfaces and porous materials.

10. What are the applications of LPT?

a) This method is capable of detecting discontinuities open to the surface of the material under test.

b) Penetrant method is very reliable in the detection of fatigue cracks which occur during the service life of a material.

11) What is Magnetic Particle Testing?

Magnetic Particle Testing is used for the testing of materials which can be easily magnetized. This method is capable of detecting flaws open-to-surface and just below the surface.

12) What is magnetism and what is magnet?

The ability of a ferromagnetic material to attract other ferromagnetic materials is called magnetism and the pieces with this ability are called magnets. Magnets are classified as permanent and temporary.

13) What is the principle of MPT?

When a specimen is magnetized, and magnetic lines of forces are predominantly inside the ferromagnetic material. The magnetic field introduced into the specimen is composed of magnetic lines of force. When ever there is a flaw which interrupts the flow of magnetic lines of force, some of these lines must exit and re-enter the specimen.

14) What is magnetic ink?

The magnetic particles can be applied as powder or more commonly as liquid suspension, usually known as magnetic ink. To be detected linear flaws such as cracks must be favourably oriented in relation to the direction of the magnetic field.

15) What are the magnetizing techniques used in MPT?

1) Magnetization using a magnet
2) Magnetization using an Electromagnet
3) Contact current flow method
4) Using a threading bar
5) The coil
6) Induced current flow

PART B 16 MARKS

1. Discuss briefly about LPT And its methods (16)

Penetrants are then classified by the method used to remove the excess penetrant from the part. The four methods are listed below:

- Method A - Water Washable
- Method B - Post-Emulsifiable, Lipophilic
- Method C - Solvent Removable
- Method D - Post-Emulsifiable, Hydrophilic

Water washable (Method A) penetrants can be removed from the part by rinsing with water alone. These penetrants contain an emulsifying agent (detergent) that makes it possible to wash the penetrant from the part surface with water alone. Water washable penetrants are sometimes referred to as self-emulsifying systems. Post-emulsifiable penetrants come in two varieties, lipophilic and hydrophilic. In post-emulsifiers, lipophilic systems (Method B), the penetrant is oil soluble and interacts with the oil-based emulsifier to make removal possible. Post-emulsifiable, hydrophilic systems (Method

D), use an emulsifier that is a water soluble detergent which lifts the excess penetrant from the surface of the part with a water wash. Solvent removable penetrants require the use of a solvent to remove the penetrant from the part.

Penetrants are then classified based on the strength or detectability of the indication that is produced for a number of very small and tight fatigue cracks. The five sensitivity levels are shown below:

- Level ½ - Ultra Low Sensitivity
- Level 1 - Low Sensitivity
- Level 2 - Medium Sensitivity
- Level 3 - High Sensitivity
- Level 4 - Ultra-High Sensitivity

The major US government and industry specifications currently rely on the US Air Force Materials Laboratory at Wright-Patterson Air Force Base to classify penetrants into one of the five sensitivity levels. This procedure uses titanium and Inconel specimens with small surface cracks produced in low cycle fatigue bending to classify penetrant systems. The brightness of the indication produced is measured using a photometer. The sensitivity levels and the test procedure used can be found in Military Specification MIL-I-25135 and Aerospace Material Specification 2644, Penetrant Inspection Materials.

2. How will inspect a material using LPT Explain in detail. (16)

   Dye penetrant inspection (**DPI**), also called **liquid penetrant inspection** (**LPI**) or **penetrant testing** (**PT**), is a widely applied and low-cost inspection method used to locate surface-breaking defects in all non-porous materials (metals, plastics, or ceramics). The penetrant may be applied to all non-ferrous materials and ferrous materials, although for ferrous components magnetic-particle inspection is often used instead for its subsurface detection capability. LPI is used to detect casting, forging and welding surface defects such as hairline cracks, surface porosity, leaks in new products, and fatigue cracks on in-service components

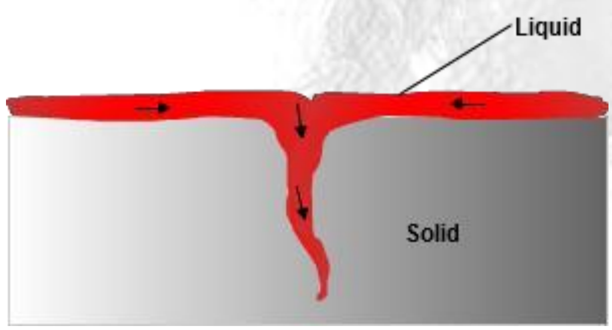
   Principles

DPI is based upon capillary action, where low surface tension fluid penetrates into clean and dry surface-breaking discontinuities. Penetrant may be applied to the test component by dipping, spraying, or brushing. After adequate penetration time has been allowed, the excess penetrant is removed and a developer is applied. The developer helps to draw penetrant out of the flaw so that an invisible indication becomes visible to the inspector. Inspection is performed under ultraviolet or white light, depending on the type of dye used - fluorescent or nonfluorescent (visible).

3. Explain in detail about the step by step procedure of inspection in LPT? (16)

Basic Processing Steps of a Liquid Penetrant Inspection

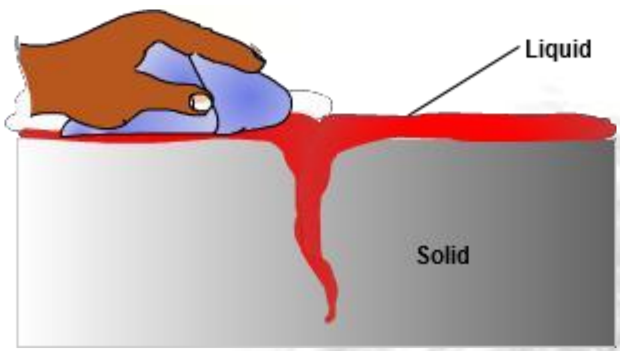
1. **Surface Preparation:** One of the most critical steps of a liquid penetrant inspection is the surface preparation. The surface must be free of oil, grease, water, or other contaminants that may prevent penetrant from entering flaws. The sample may also require etching if mechanical operations such as machining, sanding, or grit blasting have been performed. These and other mechanical operations can smear metal over the flaw opening and prevent the penetrant from entering.



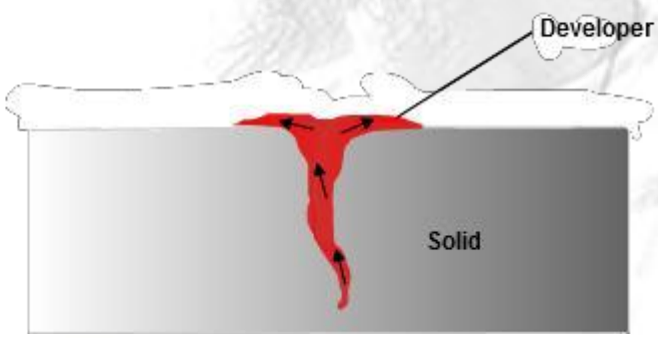
2. **Penetrant Application:** Once the surface has been thoroughly cleaned and dried, the penetrant material is applied by spraying, brushing, or immersing the part in a penetrant bath.

3. **Penetrant Dwell:** The penetrant is left on the surface for a sufficient time to allow as much penetrant as possible to be drawn from or to seep into a defect. Penetrant dwell time is the total time that the penetrant is in contact with the part surface. Dwell times are usually recommended by the penetrant producers or required by the specification being

followed. The times vary depending on the application, penetrant materials used, the material, the form of the material being inspected, and the type of defect being inspected for. Minimum dwell times typically range from five to 60 minutes. Generally, there is no harm in using a longer penetrant dwell time as long as the penetrant is not allowed to dry. The ideal dwell time is often determined by experimentation and may be very specific to a particular application.



4. **Excess Penetrant Removal:** This is the most delicate part of the inspection procedure because the excess penetrant must be removed from the surface of the sample while removing as little penetrant as possible from defects. Depending on the penetrant system used, this step may involve cleaning with a solvent, direct rinsing with water, or first treating the part with an emulsifier and then rinsing with water.



5. **Developer Application:**A thin layer of developer is then applied to the sample to draw penetrant trapped in flaws back to the surface where it will be visible. Developers come in a variety of forms that may be applied by dusting (dry powdered), dipping, or spraying (wet developers).

6. **Indication Development:** The developer is allowed to stand on the part surface for a period of time sufficient to permit the extraction of the trapped penetrant out of any surface flaws. This development time is usually a minimum of 10 minutes. Significantly longer times may be necessary for tight cracks.

7. **Inspection:** Inspection is then performed under appropriate lighting to detect indications from any flaws which may be present.

8. **Clean Surface:** The final step in the process is to thoroughly clean the part surface to remove the developer from the parts that were found to be acceptable.

4. Discuss in detail about the Principle and theory of diamagnetism? (8)

Diamagnetic materials create an induced magnetic field in a direction opposite to an externally applied magnetic field, and are repelled by the applied magnetic field. In contrast, the opposite behavior is exhibited by paramagnetic materials. **Diamagnetism** is a quantum mechanical effect that occurs in all materials; when it is the only contribution to the magnetism the material is called a *diamagnet*. Unlike aferromagnet, a diamagnet is not a permanent magnet. Its magnetic permeability is less than μ_0, the permeability of vacuum. In most materials diamagnetism is a weak effect, but a superconductor repels the magnetic field entirely, apart from a thin layer at the surface.

Theory[edit]

The electrons in a material generally circulate in orbitals, with effectively zero resistance and act like current loops. Thus it might be imagined that diamagnetism effects in general would be very, very common, since any applied magnetic field would generate currents in these loops that would oppose the change, in a similar way to superconductors, which are essentially perfect diamagnets. However, since the electrons are rigidly held in orbitals by the charge of the protons and are further constrained by the Pauli exclusion principle, many materials exhibit diamagnetism, but typically respond very little to the applied field.

5. Explain in detail about the Methods of MPT briefly (16)

   Magnetic particle Inspection (**MPI**) is a non-destructive testing (NDT) process for detecting surface and slightly subsurface discontinuities in ferromagnetic materials such asiron, nickel, cobalt, and some of their alloys. The process puts a magnetic field into the part. The piece can be magnetized by direct or indirect magnetization. Direct magnetization occurs when the electric current is passed through the test object and a magnetic field is formed in the material. Indirect magnetization occurs when no electric current is passed through the test object, but a magnetic field is applied from an outside source. The magnetic lines of force are perpendicular to the direction of the electric current, which may be either alternating current (AC) or some form of direct current (DC) (rectified AC)

Magnetic Particle Testing (MPT) is a **nondestructive examination (NDE)** technique used to detect surface and slightly subsurface flaws in most ferromagnetic materials such as iron, nickel, and cobalt, and some of their alloys. Because it does not necessitate the degree of surface preparation required by other NDE methods, conducting MPT is relatively fast and easy. This has made it one of the more commonly utilized NDE techniques out there today.

MPT is a fairly simple process with two variations: Wet Magnetic Particle Testing (WMPT) and Dry Magnetic Particle Testing (DMPT). In either one, the process begins by running a magnetic current through the component. Any **cracks or defects** in the material will interrupt the flow of current and will cause magnetism to spread out from them. This will create a “flux leakage field” at the site of the damage.

The second step involves spreading metal particles over the component. If there are any flaws on or near the surface, the flux leakage field will draw the particles to the damage site. This provides a visible indication of the approximate size and shape of the flaw.

There are several benefits of MPT compared to other NDE methods. It is highly portable, generally inexpensive, and does not need a stringent pre-cleaning operation. MPT is also one of the best options for detecting fine, shallow surface cracks. It is fast, easy, and will work through thin **coatings**. Finally, there are few limitations regarding the size/shape of test specimens.

Despite its strengths, the method is not without its limits. The material must be ferromagnetic. Likewise, the orientation and strength of the magnetic field is critical. The method only detects surface and near-to-surface defects. Those further down require alternative methods. Large currents are sometimes required to perform this method, thus "burning" of test parts is sometimes possible. In addition, once MPT has been completed, the component must be demagnetized, which can sometimes be difficult.

6. Write briefly about the theory of magnetism? How will inspect a work piece by using MPT. (16)

Principle of MPT

This testing method is called MT (Magnetic Testing) or MPT (Magnetic Particle Testing), and suitable for the surface / subsurface flaw inspection of ferromagnetic materials. Principle of MPT is as follows:

1. When the workpiece to be inspected is magnetized, magnetic flux is induced.
2. If there is a flaw on the surface, magnetic flux leaks into the air at the position of the flaw.
3. Then magnetic particles (dyed or fluorescent encapsulated) are applied to the surface.
4. These magnetic particles will migrate to the flaw where the magnetic flux leaks and forms a flaw indication that is several tens of times of actual flaw width.
5. The inspector visually identifies the flaw.

Procedure of MPT is **"Pre-cleaning" - "Magnetization" - "Applying magnetic particle" - "Observation" - "Post-cleaning"**.

(1) Pre-cleaning

Oil, paint, rust and other foreign materials on the surface to be inspected not only prevent attraction of magnetic particles to the flux leakage, but also lead to form a false indication.Therefore such materials will be cleaned chemically or mechanically before magnetization process.

(2) Magnetization

The workpiece is magnetized as direction of magnetic flux is orthogonal to direction of a flaw. Following method is applied for proper magnetization.

1. Axial current method : To pass electric current longitudinal direction of the workpiece
2. Cross current method : To pass electric current cross direction of axis of the workpiece
3. Prod method : To pass electric current between two prods contacted inspection area of the workpiece
4. Through conductor method : To pass electrical current through the hole of the workpiece
5. Coil method : Put the workpiece in a magnetizing coil
6. Yoke method : Put the workpiece between magnetic poles
7. Through flux method : To pass magnetic flux through the hole of the workpiece

(3) Applying magnetic particle

1. Types of magnetic particle
   Easy magnetization and migration to flux leakage and discriminative flaw indication are required for performance of magnetic particle.
   There are two types of magnetic particle, one is non-fluorescent particle (white, red, black) for observation under visible light, and the other is fluorescent magnetic particle for observation under UV light.
   Dry method, magnetic particle is applied to the surface as it stands, and wet method, magnetic particle is dispersed in oil or water, are applied.
2. Applying timing of magnetic particle
   There are two methods. Magnetic particle is applied during magnetization of the workpiece, or applied after ceasing magnetization. In later case residual magnetism is utilized for forming flaw indication.

(4)Observation

UV light is used for observation of the workpiece under dark environment in case of using fluorescent magnetic particle for inspection.

(5)Post-cleaning

Demagnetization, removing residual magnetic particle and rust proofing of the workpiece are done if required.

UNIT-III

THERMOGRAPHY AND EDDY CURRENT TESTING (ET)

1. What is meant by ECT?

Electrical currents (eddy currents) are generated in a conductive material by a changing magnetic field. The strength of these eddy currents can be measured. Material defects cause interruptions in the flow of the eddy currents which alert the inspector to the presence of a defect. Eddy currents are also affected by the electrical conductivity and magnetic permeability of a material, which makes it possible to sort some materials based on these properties.

2. What are the applications of eddy current testing?

- surface breaking cracks
- tube inspection
- Conductivity
- heat treat verification
- thickness of thin materials
- thickness of coatings

3. What are the advantages of eddy current testing?

- sensitive to small cracks and other defects
- detects surface and near surface defects
- inspection gives immediate results
- equipment is very portable
- method can be used for much more than flaw detection
- minimum part preparation is required
- test probe does not need to contact the part
- inspects complex shapes and sizes of conductive materials

4. What are the limitations of eddy current testing?

- Only conductive materials can be inspected
- Surface must be accessible to the probe
- Skill and training required is more extensive than other techniques
- Surface finish and roughness may interfere
- Reference standards needed for setup
- Depth of penetration is limited
- Flaws such as delaminating that lie parallel to the probe coil winding and probe scan

direction are undetectable

6. Give some American standards for ECT

ASME 243- electromagnetic (eddy current) testing of seamless copper and copper alloy tubes ASME 309 -eddy current examination of steel tubular products using magnetic saturation

ASME 376 -measuring coating thickness by magnetic field or eddy current (electromagnetic) test

7. Give the types of advanced testing methods in ECT

- magneto-optic/eddy current imaging (MOI)
- Pulsed eddy current testing
- Low frequency eddy current testing
- Squid based eddy current testing

8. Give some of the factors affecting eddy

current Test parameters

- frequency
- type and geometry of test coil
- fill factor

Test object

- electrical conductivity
- magnetic permeability
- dimensions
- temperature

9. What is the instrumentation used in ECT?

- coil
- eddy current generation
- Eddy current detection
- coil arrangement
- probe selection
- probe size Requirements

10. How is the probe size determined in

ECT? Probe size is determined by fill

factor

fill

factor=d_1^2/d_2^2 d_1-

diameter of probe. d_2-

ID of tube.

11. Briefly explain about UST?

In ultrasonic testing, high-frequency sound waves are transmitted into a material to detect imperfections or to locate changes in material properties. The most commonly used ultrasonic testing technique is pulse echo, whereby sound is introduced into a test object and reflections (echoes) from internal imperfections or the part's geometrical surfaces are returned to a receiver.

12. Name some of the couplant used in UST

- oil
- grease
- glycerin

13. What is acoustic impedance?

The resistance offered to the propagation of ultrasonic wave by a material is known as acoustic impedance (Z).

$Z = p\ .v$

p=density of the material

v=sound velocity in the material

14. How are the ultrasonic wave classified based on the vibration of particle of medium with respect to propagation

a. longitudinal waves

b. transverse waves

c. Rayleigh waves

15. How is the velocity of the sound measured?

The velocity of the sound is measured using the formula

$v= f.\ l$

v=velocity

f=frequency

l=wavelength

16. What are the types of ultrasonic probes?
    - normal probe
    - angle probe

PART B 16 MARKS

1. **Explain how the ECT is carried out**

   Eddy-current testing (also commonly seen as **eddy current testing** and **ECT**) is one of many electromagnetic testing methods used in nondestructive testing (NDT) making use of electromagnetic induction to detect and characterize surface and sub-surface flaws in conductive materials.

   ECT principle.

   In its most basic form — the single-element ECT probe — a coil of conductive wire is excited with an alternating electrical current. This wire coil produces an alternating magnetic field around itself in the direction ascertained by the right-hand rule. The magnetic field oscillates at the same frequency as the current running through the coil. When the coil approaches a conductive material, currents opposed to the ones in the coil are induced in the material — eddy currents.

   Variations in the electrical conductivity and magnetic permeability of the test object, and the presence of defects causes a change in eddy current and a corresponding change in phase and amplitude that can be detected by measuring the impedance changes in the coil, which is a telltale sign of the presence of defects.[3] This is the basis of standard (pancake coil) ECT.

   ECT has a very wide range of applications. Because ECT is electrical in nature, it is limited to conductive material. There are also physical limits to generating eddy currents and depth of penetration (skin depth).

2. Explain in detail about low ECT.

   APPLICATIONS

The two major applications of eddy current testing are surface inspection and tubing inspections. Surface inspection is used extensively in the aerospace industry, but also in thepetrochemical industry. The technique is very sensitive and can detect tight cracks. Surface inspection can be performed both on ferromagnetic and non-ferromagnetic materials.

Tubing inspection is generally limited to non-ferromagnetic tubing and is known as conventional eddy current testing. Conventional ECT is used for inspecting steam generator tubing in nuclear plants and heat exchangers tubing in power and petrochemical industries. The technique is very sensitive to detect and size pits. Wall loss or corrosion can be detected but sizing is not accurate.

A variation of conventional ECT for partially magnetic materials is full saturation ECT. In this technique, permeability variations are suppressed by applying a magnetic field. The saturation probes contain conventional eddy current coils and magnets. This inspection is used on partially ferromagnetic materials such as nickel alloys, duplex alloys, and thin-ferromagnetic materials such as ferritic chromium molybdenum stainless steel. The application of a saturation eddy current technique depends on the permeability of the material, tube thickness, and diameter.[7]

A method used for carbon steel tubing is remote field eddy current testing. This method is sensitive to general wall loss and not sensitive to small pits and cracks.

ECT on Surfaces.

When it comes to surface applications, the performance of any given inspection technique depends greatly on the specific conditions — mostly the types of materials and defects, but also surface conditions, etc. However, in most situations, the following are true:

- Effective on coatings/paint: yes
- Computerized record keeping: partial
- 3D/Advanced imaging: none
- User dependence: high
- Speed: low
- Post-inspection analysis: none

- Requires chemicals/consumables: n

3. Bubble testing

Bubble Test

Bubble Test is primarily used for testing of oil field inhibitors using the Bubble Test technique. Other names for this test include the Kettle Test and Inhibitor Screening. They are all tests that use the LPR technique with respect to time to calculate the efficiency of oil field inhibitors.

A series of LPR tests are collected over time, giving Corrosion Rate results. Cells (or Channels) are assigned together into Groups, each group has an Add Inhibitor button, once pressed, corrosion rates can be calculated for 3 periods - prior to Add Inhibitor, after 2 hours and after 16 hours (configurable), this enables Percentage Protection to be calculated.

The standard Bubble Test uses a series of Linear Polarisation Tests over a period of about 24 hours to assess the performance of a corrosion inhibitor. In simple terms it does not give an indication of localised corrosion. However, up to 80% of pipeline failures are ascribed to pitting, but very few monitoring methods are capable to show this outcome. LCM™ attempts to give the user this information as well as the standard Bubble Test information. The test preparation and duration is the same as for a standard three electrode Bubble Test using an Auxiliary, Corrosion Resistant Reference and Test

Electrode. The standard Bubble Test data is achieved with or without the addition of LCM™. LCM™ just gives additional information relating to the magnitude and frequency of pitting events.

LCM™ is simple and basically uses Ohms Law and jargon to convert potential transients into charge and metal loss by localised corrosion.

During a localised event electrons are liberated leading to a drop in potential. Once the active localised area is reinhibited, the excess electrons are consumed by the Cathodic reaction and the potential rises again. This can be seen as a potential transient. The trick is to convert this potential transient in to charge using Ohms Law, something we are all generally familiar with.

Ohm's Law $R = V / I$

$I = V / R$

V in this case is the potential shift caused by the localised event from the rest potential.

R is the polarisation resistance measured by the LPR technique.

Thus by detecting a potential transient for duration and magnitude, it is possible to calculate the charge associated with the transient and by inference, the amount of metal loss necessary to produce such a transient.

Data is presented in the form of a Histogram showing Number of Localised Events on the y axis and bins representing charge on the x axis. Adjacent bins increase in magnitude by a factor of 10. It’s all to do with relative size and volume, for instance a football that is twice as wide, has a volume that is 8 times as much. A localised event with a measured charge that is ten times greater than a previous event is likely to be produced by a pit that looks approximately twice as big.

Data from these bins is further presented with respect to time. The axis in this case are accumulated charge, or by inference metal loss, v time on the x axis. This enables the operator to add additional inhibitor and see what concentration is necessary to stop large localised events from occurring.

A version of the technique was first used by Prof John Sykes and one of his students on passive metals where a bigger polarisation was used to calibrate transients due to the non linearity of corrosion reactions. However in an inhibited system the overriding parameter that inhibits polarisation is the resistive inhibitor film, thus a doubling of polarisation is likely to simply double the polarisation current, the polarisation resistance remaining very similar. Thus for LCM™ in inhibited systems a simple LPR polarisation is deemed to be good enough for calibration.

A good paper to read relating to LCM™ is “In Situ Assessment of Pitting Corrosion and Its Inhibition Using a Localized Corrosion Monitoring Technique” Corrosion June 2010. The corresponding author was Jeremy Moloney. The paper won awards at a NACE conference.

Jeremy, funded by Baker Petrolite, used an expensive microscope to scan for pit volumes in order to get good correlation with the monitoring technique. Somewhat cheaper methods may involve making moulds of the pitted surface, then cutting off the moulds caused by the pits using a scalpel. Flowable silicon is suggested for this task. These pit models can then be weighed and simple maths used to convert to metal loss.

The LCM™ software uses a series of tools to analyse the data. These tools can be individually manipulated or massed together in a Tool Box. The idea is that corrosion test data can simply be passed through the Tool Box to produce data in a readily understandable format without need for significant analysis.

The LCM™ technique can be fitted as an option to the **Gill AC**, **Field Machine** and multiple channel instruments such as the **Gill 8** or **Gill 12** with simultaneous monitoring on all channels

HELIUM LEAK DETECTOR

A Helium Leak detector, also known as a Mass Spectrometer Leak Detector (MSLD), is used to locate and measure the size of leaks into or out of a system or containing device. The tracer gas, helium, is introduced to a test part that is connected to the leak detector. The helium leaking through the test part enters through the system and this partial pressure is measured and the results are displayed on a meter.

Helium leak detectors consists of the following components:

- A spectrometer to detect the mass of helium
- A vacuum system to maintain the pressure in the spectrometer
- A mechanical pump to evacuate the part to be tested
- Valves which enable the various stages of detection: evacuation, test & venting
- An amplifier and readout instrumentation to monitor the output signal
- Power supplies and controls
- Fixturing that attaches the part to be tested to the detector

Methods of Leak Testing Parts

There are two main methods to leak test parts using helium: Vacuum Testing (outside-in) and Pressure Testing (Inside-out). The detection method should be selected based on the working conditions of the part to be tested. It is important to maintain the same pressure conditions during the test as will exist during the actual use of the part. Vacuum systems should be tested with a vacuum inside the chamber. A compressed air cylinder should be tested with high pressure inside the cylinder.

4. How do you inspect the casting defects using NDT?

Infrared thermography (**IRT**), **thermal imaging**, and **thermal video** are examples of infrared imaging science. Thermographic camerasusually detect radiation in the long-infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 µm) and produce images of that radiation, called **thermograms**. Since infrared radiation is emitted by all objects with a temperature above absolute zero according to the black body radiation law, thermography makes it possible to see one's environment with or without visibleillumination. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night. As a result, thermography is particularly useful to the military and other users of surveillance cameras.

Some physiological changes in human beings and other warm-blooded animals can also be monitored with thermal imaging during clinical diagnostics. Thermography is used in allergy detection and veterinary medicine. It is also used for breast screening, though primarily by alternative practitioners as it is considerably less accurate and specific than competing techniques. Government and airport personnel used thermography to detect suspected swine flu cases during the 2009 pandemic

Thermography has a long history, although its use has increased dramatically with the commercial and industrial applications of the past fifty years. Firefighters use thermography to see through smoke, to find persons, and to localize the base of a fire. Maintenance technicians use thermography to locate overheating joints and sections of power lines, which are a sign of impending failure. Building construction technicians can see thermal signatures that indicate heat leaks in faulty thermal insulation and can use the results to improve the efficiency of heating and air-conditioning units.

ACTIVE THERMOGRAPHY

In **active thermography**, an energy source is required to produce a thermal contrast between the feature of interest and the background. The active approach is necessary in many cases given that the inspected parts are usually in equilibrium with the surroundings.

5. Write the capabilities of different NDT methods for detection of defects at various stages of manufacturing by using thermography.

Advantages of thermography

- It shows a visual picture so temperatures over a large area can be compared
- It is capable of catching moving targets in real time
- It is able to find deteriorating, i.e., higher temperature components prior to their failure
- It can be used to measure or observe in areas inaccessible or hazardous for other methods
- It is a non-destructive test method
- It can be used to find defects in shafts, pipes, and other metal or plastic parts
- It can be used to detect objects in dark areas
- It has some medical application, essentially in physiotherapy

Electrical Systems

Commonly Inspected Components

Abnormal heating associated with high resistance or excessive current flow is the main cause of many problems in electrical systems. Infrared thermography allows us to see these invisible thermal signatures of impending damage before the damage occurs. When current flows through an electric circuit, part of the electrical energy is converted into heat energy. This is normal. But, if there is an abnormally high resistance in the circuit or abnormally high current flow, abnormally high heat is generated which is wasteful, potentially damaging and not normal.

Ohm's law (P=I2R) describes the relationship between current, electrical resistance, and the power or heat energy generated. We use high electrical resistance for positive results like heat in a toaster or light in a light bulb. However sometimes unwanted heat is generated that result in costly damage. Under-sized conductors, loose connections or excessive current flow may cause abnormally high unwanted heating that result in dangerously hot electrical circuits. Components can literally become hot enough to melt.

Thermal imagers enable us to see the heat signatures associated with high electrical resistance long before the circuit becomes hot enough to cause an outage or explosion. Be aware of two basic thermal patterns associated with electrical failure: 1) a high resistance caused by poor surface contact and 2) an over loaded circuit or multi-phase imbalance problem.

UNIT-IV

ULTRASONIC TESTING (UT) AND ACOUSTIC EMISSION (AE)

1. What is radiography?

RT involves the use of penetrating gamma- or X-radiation to examine material's and product's defects and internal features. An X-ray machine or radioactive isotope is used as a source of radiation. Radiation is directed through a part and onto film or other media. The resulting shadowgraph shows the internal features and soundness of the part. Material thickness and density changes are indicated as lighter or darker areas on the film. The darker areas in the radiograph below represent internal voids in the component.

2. What are the applications of radiography?

Internal defects such as

- Porosity
- Voids
- Planar defects

3. What are the sources of electromagnetic radiation?

- x-ray source
- high energy x-ray source
- gamma ray source

4. Give the properties of X ray & Gamma ray

- They are not detected by human senses (cannot be seen, heard, felt, etc.).
- They travel in straight lines at the speed of light.
- Their paths cannot be changed by electrical or magnetic fields.
- They can be diffracted to a small degree at interfaces between two different materials.
- They pass through matter until they have a chance encounter with an atomic particle.
- Their degree of penetration depends on their energy and the matter they are traveling through.
- They have enough energy to ionize matter and can damage or destroy living cells.

5. Explain in brief about radiation attenuation in the specimen

When X rays are passed through the specimen they get attenuated & reduced in intensity

The modes of absorption are:

- Photoelectric effect
- Rayleigh scattering
- Compton scattering
- Pair production

It is given by the formula

$I=I_0Be^{-ux}$

6. What is the effect of radiation on the film?

- Film ionization
- Inherent unsharpness

7. What are the factors affecting the radiographic imaging?

- Geometric factors
- Radiographic film
- Intensifying screen
- Film density
- Radiographic sensitivity
- penetrameter

8. What is the inspection techniques radiography?

- Single wall single image technique
- Double wall penetration technique
- Latitude technique
- Special technique

9. What are the types of double wall penetration technique?

- Double wall single image technique
- Double wall double image technique
- Superimposing technique

10. What are the type's special techniques in radiography?

- Multiwall single image technique
- Multiwall wall Double image technique

11. What are the aspects of safety in industrial radiography

There are two types

- Monitoring radiation dosage
- Protection of personnel

12. What are the types of radiation monitoring in radiography

- ✓ Area monitoring
- ✓ Personnel monitoring

13.what is penetrameter?

A penitrameter is a guage which is used to establish radiographic technique or quality level.It is also known as image quality indicator.

14. What are the advantages of micro focal radiography

- Projection magnification
- Improved radiographic contrast
- Possibility of object manipulation

PART B 16 MARKS

1. Evaluate the application and importance of ultrasonic waves in ultra sound scanning.

Ultrasonic Testing (UT) uses high frequency sound energy to conduct examinations and make measurements. **Ultrasonic** inspection can be used for flaw detection/evaluation, dimensional measurements, material characterization, and more.

Ultrasonic testing (**UT**) is a family of non-destructive testing techniques based on the propagation ofultrasonic waves in the object or material tested. In most common UT applications, very short ultrasonic pulse-waves with center frequencies ranging from 0.1-15 MHz, and occasionally up to 50 MHz, are transmitted into materials to detect internal flaws or to characterize materials. A common example isultrasonic thickness measurement, which tests the thickness of the test object, for example, to monitor pipework corrosion.

Advantages

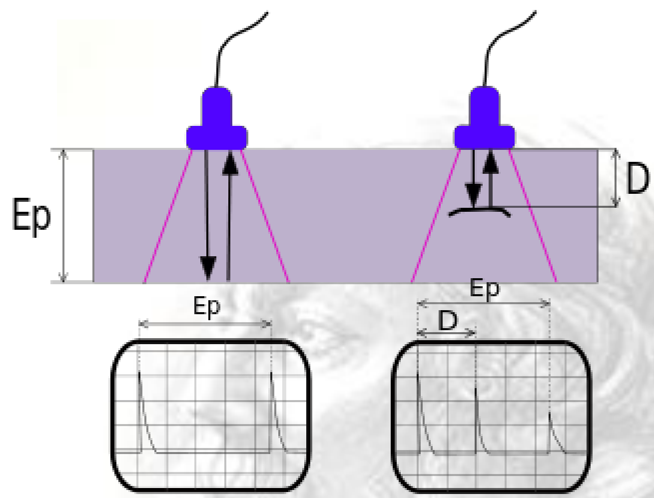
1. High penetrating power, which allows the detection of flaws deep in the part.
2. High sensitivity, permitting the detection of extremely small flaws.
3. In many cases only one surface needs to be accessible.
4. Greater accuracy than other nondestructive methods in determining the depth of internal flaws and the thickness of parts with parallel surfaces.
5. Some capability of estimating the size, orientation, shape and nature of defects.
6. Some capability of estimating the structure of alloys of components with different acoustic properties
7. Non hazardous to operations or to nearby personnel and has no effect on equipment and materials in the vicinity.
8. Capable of portable or highly automated operation.
9. Results are immediate. Hence on the spot decisions can be made.

Disadvantages

1. Manual operation requires careful attention by experienced technicians. The transducers alert to both normal structure of some materials, tolerable anomalies of other specimens (both termed "noise") and to faults therein severe enough to compromise specimen integrity. These signals must be distinguished by a skilled technician, possibly requiring follow up with other nondestructive testing methods.[1]
2. Extensive technical knowledge is required for the development of inspection procedures.
3. Parts that are rough, irregular in shape, very small or thin, or not homogeneous are difficult to inspect.
4. Surface must be prepared by cleaning and removing loose scale, paint, etc., although paint that is properly bonded to a surface need not be removed.
5. Couplants are needed to provide effective transfer of ultrasonic wave energy between transducers and parts being inspected unless a non-contact technique is used. Non-contact techniques include Laser and Electro Magnetic Acoustic Transducers (EMAT).

6. Inspected items must be water resistant, when using water based couplants that do not contain rust inhibitors.

Ultrasound is acoustic (sound) energy in the form of waves having a frequency above the human hearing range. The highest frequency that the human ear can detect is approximately 20 thousand cycles per second (20,000 Hz). This is where the sonic **range ends, and where the** ultrasonic **range begins.**



2. Illustrate the functions and applications of AMT with reference to astronomical surveying.

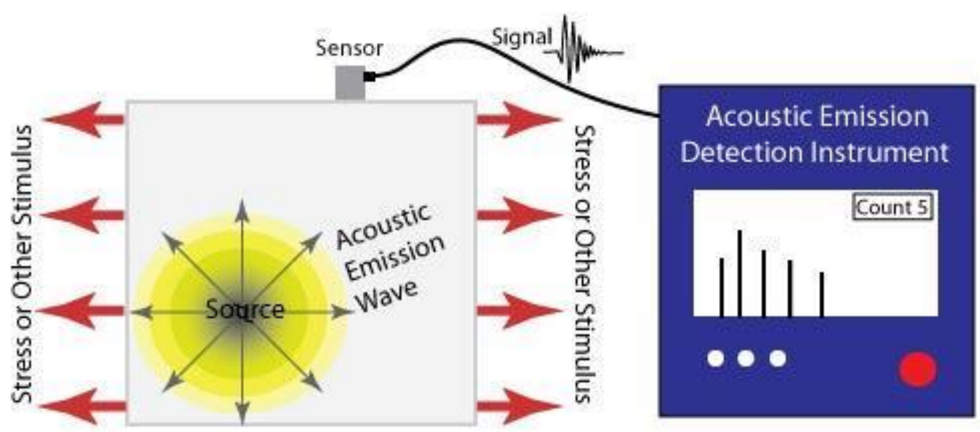
Acoustic emission (AE) is the phenomenon of radiation of acoustic (elastic) waves in solids that occurs when a material undergoes irreversible changes in its internal structure, for example as a result of crack formation or plastic deformation due to aging, temperature gradients or external mechanical forces

The application of acoustic emission to non-destructive testing of materials, typically takes place between 100 kHz and 1 MHz. Unlike conventional ultrasonic testing, AE tools are designed for monitoring acoustic emissions produced within the material during failure or stress, rather than actively transmitting waves, then collecting them after they have traveled through the material. Part failure can be documented during unattended monitoring. The monitoring of the level of AE activity during multiple load cycles forms the basis for many AE safety inspection methods, that allow the parts undergoing inspection to remain in service.[6]

The technique is used, for example, to study the formation of cracks during the welding process, as opposed to locating them after the weld has been formed with the more familiar ultrasonic testing technique. In a material under active stress, such as some components of an airplane during flight, transducers mounted in an area can detect the formation of a crack at the moment it begins propagating. A group of transducers can be used to record signals, then locate the precise area of their origin by measuring the time for the sound to reach different transducers. The technique is also valuable for detecting cracks forming in pressure vessels [7][8] and pipelines transporting liquids under high pressures. Also, this technique is used for estimation of corrosion in reinforced concrete structures.[6][9]

In addition to non-destructive testing, acoustic emission monitoring has applications in process monitoring. Applications where acoustic emission monitoring has successfully been used include detecting anomalies in fluidized beds, and end points in batch granulation.

Standards for the use of acoustic emission for non-destructive testing of pressure vessels have been developed by the ASME, ISO and the European Community.



3. Describe the application and importance of magnetic resonance waves in medical scanning.

Magnetic resonance imaging (**MRI**) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body in both health and disease. MRI scanners use strong magnetic fields, radio waves, and field gradients to generate images of the inside of the body.

MRI is based upon the science of nuclear magnetic resonance (NMR). Certain atomic nuclei can absorb and emit radio frequencyenergy when placed in an external magnetic field. In clinical and research MRI, hydrogen atoms are most-often used to generate a detectable radio-frequency signal that is received by antennas in close proximity to the anatomy being examined. Hydrogen atoms exist naturally in people and other biological organisms in abundance, particularly in water and fat. For this reason, most MRI scans essentially map the location of water and fat in the body. Pulses of radio waves excite the nuclear spin energy transition, and magnetic field gradients localize the signal in space. By varying the parameters of the pulse sequence, different contrasts can be generated between tissues based on the relaxation properties of the hydrogen atoms therein. Since its early development in the 1970s and 1980s, MRI has proven to be a highly versatile imaging technique. While MRI is most prominently used in diagnostic medicine and biomedical research, it can also be used to form images of non-living objects. MRI scans are capable of producing a variety of chemical and physical data, in addition to detailed spatial images.

4. Discuss the functions and application of instrumentation in anti lock braking system.

An **anti-lock braking system** or **anti-skid braking system** (**ABS**) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding. It is an automated system that uses the principles of threshold braking and cadence braking which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than many drivers could manage.

ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces; however, on loose gravel or snow-covered surfaces, ABS can significantly increase braking distance, although still improving vehicle steering control.

Since initial widespread use in production cars, anti-lock braking systems have been improved considerably. Recent versions not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias. This function, depending on its specific capabilities.

There are four main components of ABS: wheel speed sensors, valves, a pump, and a controller.

Speed sensors

A speed sensor is used to determine the acceleration or deceleration of the wheel. These sensors use a magnet and a Hall effect sensor, or a toothed wheel and anelectromagnetic coil to generate a signal. The rotation of the wheel or differential induces a magnetic field around the sensor. The fluctuations of this magnetic field generate a voltage in the sensor. Since the voltage induced in the sensor is a result of the rotating wheel, this sensor can become inaccurate at slow speeds. The slower rotation of the wheel can cause inaccurate fluctuations in the magnetic field and thus cause inaccurate readings to the controller.

Valves

There is a valve in the brake line of each brake controlled by the ABS. On some systems, the valve has three positions:

- In position one, the valve is open; pressure from the master cylinder is passed right through to the brake.
- In position two, the valve blocks the line, isolating that brake from the master cylinder. This prevents the pressure from rising further should the driver push the brake pedal harder.
- In position three, the valve releases some of the pressure from the brake.

The majority of problems with the valve system occur due to clogged valves. When a valve is clogged it is unable to open, close, or change position. An inoperable valve will prevent the system from modulating the valves and controlling pressure supplied to the brakes.

Pump

The pump in the ABS is used to restore the pressure to the hydraulic brakes after the valves have released it. A signal from the controller will release the valve at the detection of wheel slip. After a valve release the pressure supplied from the user, the pump is used to restore a desired amount of pressure to the braking system. The controller will modulate the pumps status in order to provide the desired amount of pressure and reduce slipping.

Controller

The controller is an ECU type unit in the car which receives information from each individual wheel speed sensor, in turn if a wheel loses traction the signal is sent to the controller, the controller will then limit the brake force (EBD) and activate the ABS modulator which actuates the braking valves on and off.

UNIT V
RADIOGRAPHY (RT)

1. What is acoustic emission testing?

AET is emerging as a powerful tool for NDE of plant components such as pressure vessels, pipes, welds etc. acoustic emission testing is defined as the class of phenomenon whereby transient elastic waves is generated by the rapid release of energy from localized sources like places of transient relaxation of stress and strain fields.

2. What is the principle of AET?

Acoustic emission inspections detects and analyze minute AE signals generated by growing discontinuities in material under a stimulus such as stress and temperature. Proper analysis of these signals can provide information concerning the detection and location of these discontinuities and structural integrity.

3. What are the type of acoustic emission observed?
   - 1.continuous
   - 2.burst
4. List some applications of AET?
   a. Inspection during proof testing and on-line monitoring of pressure vessels, pipelines and engineering structures.
   b. Leakage detection and location
   c. Quality control during fabrication
5. What is the sensitivity of AET method?

AE inspection is extremely sensitive compared with the other more familiar NDT methods. The AET can detect crack growth of the order of 25 microns. This corresponds to microcrack growth of the order of less than 10 μm.

6. List the instrumentation for AET.

The instrumentation for AET consists of signal detection, data(signal) acquisition, processing and analysis units.

7. List some factor for leak detect using Acoustic emission testing.
   a. The nature of AEradiated from leak
   b. The attenuation between leak and sensor and
   c. The background noise.
8. What is thermography.

Thermography is a type of infrared imaging science. Thermo graphic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 900–14,000 nanometers or 0.9–14 μm) and produce images of that radiation.

9. List some advantages of Thermography

   - It shows a visual picture so temperatures over a large area can be compared

- It is capable of catching moving targets in real time
- It is able to find deteriorating (i.e. at higher temperature) components prior to their failure
- It can be used to measure or observe in areas inaccessible or hazardous for other methods

10. List some factor affect the thermal measurements.
    a)Emissivity
    b)Surroundings
    c)Atmosphere
11. What are the modes available for aquire of thermal image.
    1. Image convertor
    2. Pyrincon based devices
    3. Mechanical scanning devices
12. What are all the two categories available for thermography.
    1. Passive
    2. Active
13. What is mean by passive technique.
    In passive technique, the natural heat distribution is measured over the surface of a hot structure. This is generally used in temperature monitoring.
14. What is mean by active technique?
    In an active technique, heating or cooling in included or applied to the part or the complete surface and the movement and redistribution of temperature profile across the test surface is measured. This is generally used in non destructive evaluation.
15. Name some applications of thermography
    1. Location of loose contacts on busbar joints of switchyard, switchgear, etc.
    2. Location of improper jointing of lugs in cable joints
    3. Finding irregularities in distribution boards.
16. Name some of the leak testing methods.
    1)Air/ soap solution
    2)Methanol/hydrogen 3)Hydrogen
    4)Halogen gas
    5)Hydrogen/ helium
    6)Radioactive gas
17. What are all the advantages of bubble testing.
    The advantages of bubble testing methods are that it is inexpensive, can carried out by relatively less experienced personnel, is rapid, gives accurate location of leak, and the whole specimen is inspected simultaneously.
18. Which kind of techniques are used in helium leak detector.
    a. Probe technique
    b. Envelope vacuum technique

c. Sniffer technique
d. Envelope pressure technique
e. Pressurization technique

19. List some of the defects occurred during casting.
1. Non metallic inclusions
2. Porosity
3. Blow holes
4. Shrinkage flaws macro shrinkages
5. Centerline shrinkage
6. Cold shut
7. Crack

20. Name some of the welding defects normally occurring?
1. Gas inclusions
2. Slag inclusions
3. Lack of fusion
4. Lack of penetration
5. Cracks
6. Tungsten inclusions
7. Undercut
8. Burn through
9. Root pass oxidation

PART B 16 MARKS

1. Explain the factors which affect the radiography imaging.

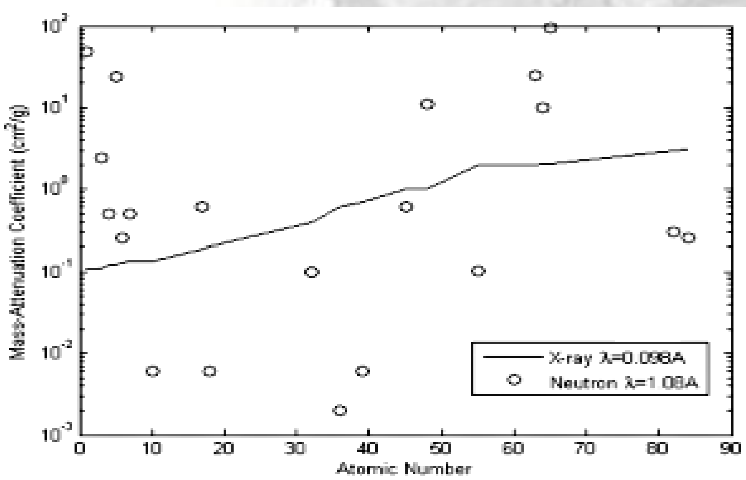
Radiography is an imaging technique that uses electromagnetic radiation other than visible light, especially X-rays, to view the internal structure of a non-uniformly composed and opaque object (i.e. a non-transparent object of varying density and composition) such as the human body. To create the image, a heterogeneous beam of X-rays is produced by an X-ray generator and is projected toward the object. A certain amount of X-ray is absorbed by the object, which is dependent on the particular density and composition of that object. The X-rays that pass through the object are captured behind the object by a detector (either photographic film or adigital detector). The detector can then provide a superimposed 2D representation of all the object's internal structures. **Contrast radiography** uses a radiocontrast agent, a type of contrast medium, to make the structures of interest stand out visually from their background, whereas **plain radiography** does not. Each type is best suited to certain indications.

In tomography, the X-ray source and detector move to blur out structures not in the focal plane. Conventional tomography is rarely used now having been replaced by CT. Computed tomography (CT scanning), unlike plain-film tomography, generates 3D representations used for computer-assisted reconstruction.

Applications of radiography include medical radiography and industrial radiography: if the object being examined is living, whether human or animal, it is regarded as medical all other radiography is regarded as industrial radiographic work orIndustrial computed tomography. The role of the Radiographer has changed dramatically as a result of more advanced equipment

2. Explain in detail about neutron radiography

Neutron radiography is a non-destructive imaging technique that uses thermal neutrons to probe the sample. Unlike X-ray, neutron only interacts with atomic nuclei. Therefore, the attenuation pattern of thermal neutron is different from X-ray. Fig. 1 shows the mass-attenuation coefficient for X-ray and neutron with given wave length. [1] The mass-attenuation coefficient μ/ρ can be defined by Beer-Lambert Law



Most work in neutron radiography is performed with thermal neutron defined as neutron with energy of about 0.025eV. There are two reasons for the choice of thermal neutron. First, neutron within this energy range can exhibit the useful attenuation feature described above; second, thermal neutron can be easily obtained. Neutron from point sources, e.g. nuclear reactor, usually has higher energy than thermal neutron and diverges in direction. Therefore, it is necessary to slow down and collimate the neutron to generate a sharp radiograph with high resolution

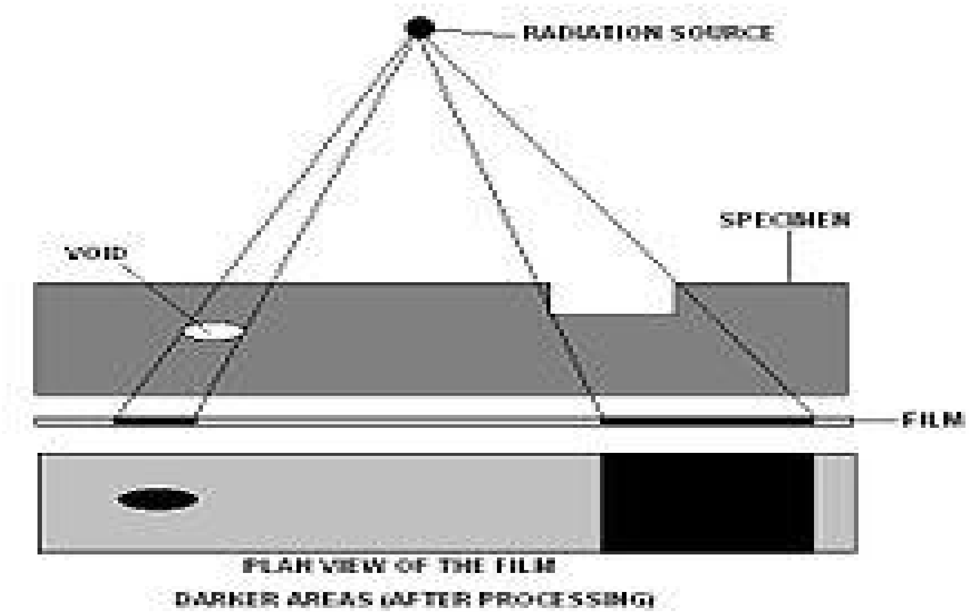
3. Briefly explain the Radiography.

In Radiography Testing the test-part is placed between the radiation source and film (or detector). The material density and thickness differences of the test-part will attenuate (i.e. reduce) the penetrating radiation through interaction processes involving scattering and/or absorption. The differences in absorption are then recorded on film(s) or through an electronic means. In industrial radiography there are several imaging methods available, techniques to display the final image, i.e. Film Radiography, Real Time Radiography (RTR), Computed Tomography (CT), Digital Radiography (DR), and Computed Radiography (CR).

There are two different radioactive sources available for industrial use; X-ray and Gamma-ray. These radiation sources use higher energy level, i.e. shorter wavelength, versions of the electromagnetic waves. Because of the radioactivity involved in radiography testing, it is of paramount importance to ensure that the Local Rules is strictly adhered during operation.

Computed Tomography (CT) is one of the lab based advanced NDT methodsthat TWI offers to industry. CT is a radiographic based technique that provides both cross-sectional and 3D volume images of the object under inspection. These images allow the internal structure of the test object to be inspected without the inherent superimposition associated with 2D radiography. This feature allows detailed analysis of the internal structure of a wide range of components.

Industrial radiography is the use of ionizing radiation to view objects in a way that cannot be seen otherwise. It is not to be confused with the use of ionizing radiation to change or modify objects; radiography's purpose is strictly viewing. Industrial radiography has grown out of engineering, and is a major element of nondestructive testing. It is a method of inspecting materials for hidden flaws by using the ability of short X-rays and gamma rays to penetrate various materials. Two ways to inspect materials for flaws is to utilize X-ray computed tomography or Industrial computed tomography scanning.



Inspection of products

Gamma radiation sources, most commonly iridium-192 and cobalt-60, are used to inspect a variety of materials. The vast majority of radiography concerns the testing and grading of welds on pressurized piping, pressure vessels, high-capacity storage containers, pipelines, and some structural welds. Other tested materials include concrete (locating rebar or conduit), welder's test coupons, machined parts, plate metal, or pipewall (locating anomalies due to corrosion or mechanical damage). Non-metal components such as ceramics used in the aerospace industries are also regularly tested.

4. Write short notes Fluroscophy.

Fluoroscopy is a type of medical imaging that shows a continuous X-ray image on a monitor, much like an X-ray movie. During a fluoroscopy procedure, an X-ray beam is passed through the body. The image is transmitted to a monitor so the movement of a body part or of an instrument or contrast agent (“X-ray dye”) through the body can be seen in detail.

Benefits/Risks

Fluoroscopy is used in a wide variety of examinations and procedures to diagnose or treat patients. Some examples are:

- Barium X-rays and enemas (to view the gastrointestinal tract)

- Catheter insertion and manipulation (to direct the movement of a catheter through blood vessels, bile ducts or the urinary system)
- Placement of devices within the body, such as stents (to open narrowed or blocked blood vessels)
- Angiograms (to visualize blood vessels and organs)
- Orthopedic surgery (to guide joint replacements and treatment of fractures)

Angiographic systems used for interventional procedures have a digital acquisition or "**cine**" mode. A high radiation dose rate is used to obtain a series of high-resolution images with reduced image noise. The radiation dose per frame for digital acquisitions can be 15 times greater than for **fluoroscopy**.